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ORIGINAL RESEARCH

Irukandji and *Chironex fleckeri* jellyfish envenomation in tropical Australia

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Objective.—To compare the temporal distribution of Irukandji and *Chironex fleckeri* stings, the demographics of victims, the prevailing physical conditions at the time of a sting, and the prevalence of unsuitable first aid strategies.

Methods.—Retrospective assessment of 478 *Chironex* and 544 Irukandji stings in Queensland and the Northern Territory of Australia.

Results.—Adolescent and young adult males were the most common victims of Irukandji (median age 21 years) and *Chironex* stings (median age 16 years). Most *Chironex* stings occurred on the legs, while Irukandji stings were more common on the arms. Vinegar was correctly used to remove tentacles in 90.5% of *Chironex* stings, whereas inappropriate treatments were used in the remaining cases. *Chironex* stings were reported in every month in the Northern Territory, and in all months but June and July in Queensland. The peak prevalence for *Chironex* stings occurred in January in both areas, while the number of Irukandji stings peaked in December in Queensland and in May in the Northern Territory. *Chironex* stings were more common on still, cloudy days, whereas Irukandji stings were more common on still, clear days. Irukandji stings were more frequent than *Chironex* stings on rough days (P = .0005). *Chironex* and Irukandji stings were similar with respect to tides, moon phases, and rainfall.

Conclusions.—This study failed to predict exact weather patterns or other contributing factors to reduce the risk of stings to an acceptable level, but did identify several factors that increase the incidence of stings. The "stinger-free" season reported on *Chironex* warning signs is inaccurate and should be changed to warn bathers that *Chironex* may be present year round, particularly in the Northern Territory.

Key words: Carukia barnesi, Chironex fleckeri, Irukandji, jellyfish, envenomation, marine stings, Cnidaria

Introduction

Each year in tropical Australia (the area from just north of Agnes Water, Queensland, around the northern coast and then south to Exmouth in West Australia), serious envenomations occur due to jellyfish stings (Figure 1). There are a number of jellyfish species that cause stings in this area, but *Chironex fleckeri,* often known as the *Chironex* box jellyfish (or North Australian box jellyfish), have caused 67 reported fatal stings since 1883. The number of stings varies from approximately 50 to 200 stings each year and includes small stings that cause severe local pain, as well as larger life-threatening stings that affect the conscious state, breathing, or circulation of the victim. Similar species occur in the tropical and subtropical waters of the majority of west Indo-Pacific countries. Up to 20 to 50 deaths occur each year from a similar species of jellyfish in the Philippines.[1]

Carukia barnesi (and similarly related species), commonly known as the Irukandji, causes stings that trigger severe systemic symptoms. The number of stings varies considerably from year to year, from a handful to several hundred. In some years they may cause potentially life-threatening stings, whereas in other years they cause severe systemic symptoms only; this variability is not currently understood.

Although the problem of severe jellyfish stings is well known in tropical Australian waters, little information is

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Figure 1. Distribution of *Chironex* and Irukandji jellyfish in tropical Australian waters from north of Agnes Water, Queensland to Exmouth in West Australia.

available on how, why, or when they occur. Barnes' simple observations of *Chironex*[2] gave a basis for our knowledge, but the epidemiology of the Irukandji and related jellyfish is as yet unknown, although current research is underway by Surf Life Saving Australia to rectify this.

In 1944, Southcott first noticed 2 different syndromes caused by jellyfish stings in troops stationed in north Queensland during the war.[3] In one syndrome, there were severe skin pain and markings, and in the other there was a minor skin mark, but severe systemic symptoms were delayed.

THE IRUKANDJI AND IRUKANDJI SYNDROME

The organism responsible for the delayed severe systemic symptoms was not known, but in 1952 Flecker named the disorder the Irukandji syndrome[4] after the Aboriginal tribe that inhabited the region from the Mowbray River in the north to Trinity Islet in the south, where many of the stings occurred. It was not until some careful detective work by Barnes in 1966[5] that he caught a small jellyfish. After testing the sting of this jellyfish on themselves, Barnes, his son, and a lifesaver ended up in the Cairns Hospital Intensive Care Unit with the typical Irukandji syndrome (this is not a recommended procedure!). The specimens were sent to Southcott for identification, and this small jellyfish was named *Carukia barnesi,* after its intrepid discoverer.[6]

DEFINITION OF IRUKANDJI SYNDROME

From the original descriptions, Irukandji syndrome can be defined as follows:

> The systemic symptoms developing after a sting from a small box jellyfish (carybdeid—ie, one tentacle only, arising from each of four corners): it starts with minor skin pain at the site of envenomation, followed within 5–45 (usually 30) minutes by a classical sequence of symptoms, including low back pain, muscle cramps in all 4 limbs, the abdomen, and chest, sweating, anxiety, restlessness, nausea, vomiting and headache.[5, 7, 8, 9]

More severe symptoms have been described recently and include hypertension and pulmonary edema,[7,8] toxic global heart dilatation proven by echocardiography,[9] and cerebral edema.[10] Almost all cases have to be assessed in hospital and treated with parenteral opiates for severe muscle pain. Many of the other symptoms are similar to catecholamine excess and respond to phentolamine, an α-adrenergic blocker, in 5- to 10-mg doses. Between 10% and 70% of Irukandji sting cases require hospital admission and treatment for 24 to 72 hours (P.J.F., unpublished data, 1999).

CHIRONEX FLECKERI

The jellyfish causing the syndrome with severe skin pain was discovered in 1955, when Flecker caught several large, box-shaped jellyfish after the death of a young child near Innisfail. Southcott confirmed that these animals were a new species and genus of jellyfish and named the species *Chironex fleckeri,* after Flecker.[11]

Although severe and even life-threatening stings from Irukandji have been described,[4–10] 67 deaths due to *Chironex* stings have been reported in Australia since 1883.[1,12] Stings from *Chironex,* unlike those from the Irukandji, cause instant severe skin pain, similar to being branded with burning irons. Large stings (more than 50% of the area of one limb) may cause impaired consciousness, breathing, and circulation, which may lead to death within 3 minutes.[1]

In *Chironex* stings, the area of envenomation depends on the width and the length of tentacles, as well as the intimacy of skin contact, which may be partially reduced due to the presence of hair. The latter factor may also be a reason why relatively hairless victims such as children, who also have a greater surface area to mass ratio, suffer more serious stings. Children account for 52 of the 67 deaths from *Chironex.*[1]

However, the majority of *Chironex* envenomations are small but cause severe local skin pain; the pain is usually relieved with cold packs or the application of ice to the stung area for 15 to 20 minutes. Although some victims are taken to the hospital, few are admitted, accounting for approximately 1% to 2% of the envenomations reported (P.J.F., unpublished data, 1999); exact numbers of cases are unobtainable. Ovine antivenin has been available since 1966 and has been used on some 250 occasions, with a transient rash in just 1 patient being the only reported side effect. In severe envenomations, the standard treatment is 1 ampoule intravenously for medical personnel or paramedics, or 3 ampoules intramuscularly for qualified ambulance officers to give on the beach. The intravenous ampoules are given and repeated when necessary—up to 12 ampoules have been suggested.[1]

Little is known about the demographics of the victims, the prevailing physical conditions at the time of the sting, or the prevalence of unsuitable first aid strategies. A retrospective study of a database held by the authors was undertaken to see if recurrent factors were associated with these stings.

Methods

A retrospective study of a computerized database kept by one of the authors (P.J.F.) was undertaken. The database contained a total of 1203 jellyfish stings and 66 stings by other marine organisms (stingrays, stonefish, etc), which occurred within tropical Australia. The majority of jellyfish stings were caused by either the Irukandji (544 cases; 45.2%) or *Chironex fleckeri* (478 cases; 39.7%). The 181 stings from other jellyfish species were excluded from analysis, because severe stings from species other than the Irukandji and *Chironex fleckeri* are uncommon in Australia.

The majority of these reports were collected from 1986 onward, but a few cases from previous years were included, although data for these early stings were often incomplete. Between 1987 and 1999 there were 5 deaths from *Chironex* stings, and another occurred in December 1999 after this analysis was completed. To date, there have been no reported deaths due to Irukandji envenomation.

Other database entries included some severe stings from other jellyfish species (n = 181; 15.1%), although such severe stings are uncommon in Australia and were therefore excluded. Data were obtained from hospitals, ambulance centers, doctors, and surf lifesavers, all of whom were all contacted by one of us (P.J.F.) and asked for reports. Other reports from newspapers were followed up for more information and carefully investigated for accuracy before inclusion in the database. Most data on sting reports were entered shortly after the sting occurred and as soon as the report was received. However, some information was obtained retrospectively, including tidal information from the Maritime Division, Queensland, and the Northern Territory Department of Transport (Harbours and Marine); weather details from the Queensland and Northern Territory weather bureaus; and phases of the moon from the Internet.[12]

Wind speed was available in kilometers per hour for the majority of stings and was converted into knots by multiplying by 0.539593. Wind strength was then classified using the adaptation of the Beaufort Wind Force Scale used by the Australian Bureau of Meteorology. In this classification, "calm" equates to 0 knots, "light winds" are between 1 and 10 knots, "moderate winds" are between 11 and 16 knots, "fresh winds" are defined as 17 to 21 knots, and 2 levels of "strong winds" are defined as being between 22 and 27 knots and between 28 and 33 knots.

STATISTICAL METHODS

Ninety-five percent confidence intervals (95% CI) have been reported for mean values. Skewness was assessed for all continuous variables, and median values have been reported in addition to means when the distribution was not normal. Bivariate analyses comparing 2 categorical variables (eg, gender vs species) were performed using χ^2 tests, and the Wilcoxon rank sum test was used to assess differences in the median age of victims between the 2 species. *T* tests were used to compare mean maximum daily air temperatures by species and location. Statistical analysis was performed using Intercooled Stata Version 4.0 for Windows.

Results

Information with sufficient detail for analysis was available for 412 *C fleckeri* stings (135 Queensland, 277 Northern Territory) and 544 Irukandji stings (496 Queensland, 48 Northern Territory).

GENDER AND AGE

Gender was available for 99% (n = 408) of the *Chironex* sting cases and 90.1% (n = 490) of the Irukandji sting cases reported from tropical Australia. Overall, considerably more males (59.8%) than females were stung. However, the sex ratios for *Chironex* and Irukandji stings differed significantly, with 64.2% of *Chironex* stings and 56.1% of Irukandji stings occurring in males (χ^2 $P = .014$).

Age was recorded for 97.6% (n = 402) of *Chironex* victims and 83.1% (n = 452) of Irukandji victims. The age of *Chironex* victims ranged from 1 to 68 years with a median of 16 years and a mean of 19.4 years (95%

Methods used in attempts to remove *Chironex fleckeri* tentacles and treat wound site

Methods	*Appropriate*	*Inappropriate*
Tentacles removed with vinegar only	226	...
Vinegar + ice/cold packs	44	...
Vinegar + compression bandage	7	...
Vinegar + sand	...	3
Vinegar + methylated spirits	...	1
Vinegar + Stingose* spray	...	2
Sand only	...	10
Sand + methylated spirits	...	2
Sand + urine	...	1
Ice/cold packs only	...	4
Alcohol/methylated spirits/water	...	3
Various	...	3
Total	**277 (90.5%)**	**29 (9.5%)**

*Stingose is an over-the-counter spray consisting of 20% aluminium sulphate solutions in water.

CI: 18.1–20.7), while the age of Irukandji victims ranged from 1 to 89 years with a median of 21 years and a mean of 21.9 years (95% CI: 20.7–23.0).

AREA STUNG

Information on the part(s) of the body stung was available for 88.3% (n = 364) of *Chironex* victims, 32.4% of whom were stung on multiple body sites. The legs were by far the most commonly affected site, accounting for 52.8% of all sites stung (n = 517) and affecting 75% of *Chironex* victims. Information on the body sites stung by Irukandji was available for 69.3% (n = 377) of victims, 21.5% of whom were stung on multiple body sites. The arms and legs were the most commonly affected sites, accounting for 28.1% and 23.1%, respectively, of all sites stung (n = 481). Almost half (48.7%) of the Irukandji victims were stung on the arms, whereas only 29.4% were stung on the legs.

FIRST AID TO REMOVE TENTACLES

Information on the presence of tentacles and attempts to remove them from the sting site, which usually occurs with *Chironex* stings, was available for 74.3% (n = 306) of *Chironex* cases, but only for 9.4% (n = 51) of Irukandji stings. The lack of information regarding the removal of Irukandji tentacles probably reflects the fact that Irukandji has small tentacles, usually inflicts a sting from the bell, and does not leave alarming wheals or remaining tentacles.

The sting sites of 90.5% of *Chironex* victims and 88.2% of Irukandji victims were flooded with vinegar (Table). However, in a small number of *Chironex* victims, vinegar was used in tandem with much less desirable measures, including rubbing with sand and dousing with methylated spirits. The majority of *Chironex* victims whose wounds were not treated appropriately tried using sand to remove the tentacles. The outcomes of the various treatments and records of antivenin use were not available.

PHYSICAL PARAMETERS

Temperature

The mean maximum daily air temperature for *Chironex* stings, based on data available for 71.8% (n = 296) of cases, was 31.2°C (95% CI: 30.9–31.4). *Chironex* stings occurred on days when the maximum daily air temperature was between 24°C and 39°C. Similarly, the mean maximum daily air temperature for Irukandji stings, based on data available for 65.6% (n = 357) of cases, was 31.2°C (95% CI: 31.0–31.5). Irukandji stings only occurred on days when the maximum daily air temperature was between 24°C and 40°C. The mean maximum daily air temperature did not differ by state for either species (*Chironex t* test, P = .2312; Irukandji *t* test, P = .3581). The mean maximum daily air temperature was also similar for both species (*t* test, P = .7124).

Season

In Queensland, *Chironex* stings were reported during every month of the year except June and July, with the maximum frequency (43.8%) of stings occurring in January (Figure 2). In the Northern Territory, *Chironex* stings were reported continuously throughout the year,

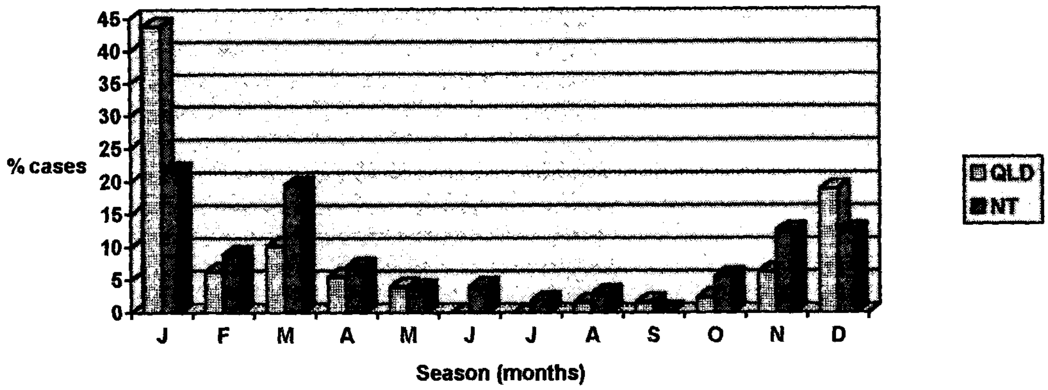

Figure 2. The distribution of *Chironex fleckeri* stings by season in Queensland and the Northern Territory.

with the maximum frequency of stings occurring in January (21.6%) and March (19.4%) (Figure 2).

In Queensland, Irukandji stings were reported during every month of the year except July and August, with the maximum frequency occurring in December and January, respectively (Figure 3). In the Northern Territory, Irukandji stings were reported during every month of the year except July, August, and February. However, in contrast to Queensland, the maximum frequency of Irukandji stings occurred in the month of May (Figure 2).

Moon phases

Information on the phase of the moon corresponding with the date of stings was available for 69.2% (n = 285) of *Chironex* stings and 64% (n = 348) of Irukandji stings. The distribution of *Chironex* and Irukandji stings was similar with respect to the phases of the moon (χ^2, $P = .317$). Both types of stings occurred most frequently during the moon's last quarter (28.8% and 30.2%, respectively) and least often during the first quarter of the moon (21.8% and 16.1%, respectively).

Tidal information

Tidal information was available for 71.6% (n = 295) of *Chironex* stings and 50.7% (n = 276) of Irukandji stings. The distribution of *Chironex* and Irukandji stings was similar with respect to the tides, with both sting types occurring most frequently during ebbing tides (43.1% of *Chironex* stings and 35.6% of Irukandji stings).

Cloud cover

Cloud cover on the day of a sting (expressed in eighths) was available for 72.6% (n = 299) of *Chironex* stings and 65.6% (n = 357) of Irukandji stings. *Chironex* stings occurred most often on days where seven eighths or six eighths of the sky was covered by cloud, accounting for 26.8% and 16.4% of all *Chironex* stings, respectively. Only 23.4% of *Chironex* stings compared to 40.6% of Irukandji stings occurred when cloud cover was less than or equal to two eighths (χ^2, $P = .0005$).

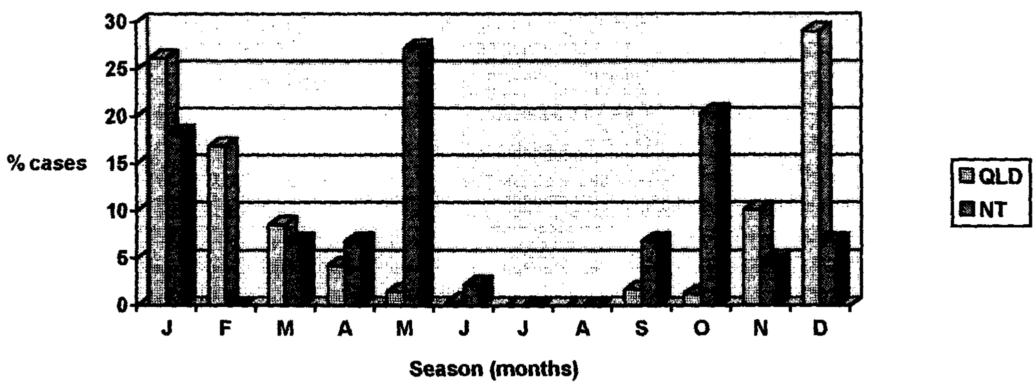

Figure 3. The distribution of Irukandji stings by season in Queensland and the Northern Territory.

Wind strength

Data on wind strength were available for 73.5% (n = 303) of *Chironex* stings and 65.1% (n = 354) of Irukandji stings. Compared to Irukandji stings, *Chironex* stings tended to occur on days with significantly lower wind speeds. The mean and median wind strengths associated with *Chironex* stings were 10 km/h and 10.9 km/h (95% CI: 10.2–11.6), respectively, compared to a mean and median of 15 km/h and 16.9 km/h (95% CI: 16.1–17.7), respectively, for Irukandji stings (Kruskal-Wallis, $P = .0001$). When wind strength was categorized using an adaptation of the Beaufort Wind Force Scale, we found that 93.1% of *Chironex* stings occurred on 0-knot days or days with light winds, 5.6% occurred on days with moderate winds, and the remaining 1.3% occurred on days with fresh winds. While the majority (73.2%) of Irukandji stings occurred on 0-knot days, or days with only light winds, a higher proportion of stings occurred on days with moderate, fresh, or strong winds (19.2%, 7.1%, and 0.6%, respectively; χ^2, $P = .0005$).

Rainfall

Daily rainfall data were available for 72.6% (n = 299) of *Chironex* stings and 65.1% (n = 354) of Irukandji stings. The majority of *Chironex* and Irukandji stings occurred on days with no rainfall (70% and 69.5% of cases, respectively). Consequently, the median daily rainfall was zero for both *Chironex* and Irukandji stings.

Discussion

Although more than 500 cases of Irukandji stings and 450 *Chironex* stings are recorded in the database, most of which have been collected during the past 10 years, this number would represent only the tip of the iceberg, with many more stings actually occurring. Some stings may have been treated at home, and some may have been treated in the hospital but not recorded. Despite the current belief that all *Chironex* stings can be fatal, most are small, although very painful, and are only a threat to life when large stings occur, particularly in children of 15 years or younger, who account for some 78% (52/67) of the total number of fatal stings.[1] As neither the ambulance service nor hospitals in Queensland have codes for categorizing jellyfish stings, the total past numbers of *Chironex* and Irukandji stings are not retrievable. Other stings occurring in the Northern Territory are often far from major hospitals and are treated at outpost missions, again leading to general underreporting of data on stings.

The male predominance seen for both Irukandji and *Chironex* stings may indicate that males are more likely to risk entering tropical waters than females. *Chironex* stings characteristically occur in very shallow water (even ankle deep) on people who are paddling or standing in the water. This explains why the majority of *Chironex* stings recorded in the database occurred on the legs. In contrast, Irukandji stings are more likely to occur when swimming in deeper water. This would explain both the higher average age of people stung by Irukandji and the body site distribution of these stings (predilection for the arms).

It is commonly believed that *Chironex* stings occur in the Northern Territory only during the wet season, which is during the summer months, with an "official end" to the stinger season falsely believed to occur on May 1; many people resume sea bathing at this time. However, *Chironex* stings were reported for every month of the year, and deaths have occurred in every month except July.[1]

In Queensland, *Chironex* stings were reported for all months except for June and July, and deaths have been reported to occur in summer months from November through May, although none have occurred from June through October.[1] The peak in the number of *Chironex* stings in both Queensland and the Northern Territory occurred in January, the hottest time of the year. Also, contrary to general belief, Irukandji stings occurred in every month except July and August in Queensland, and July, August, and February in the Northern Territory.

The peak time for Irukandji stings differed by location, with peak stings occurring in December in Queensland and in May in the Northern Territory. This difference is because fewer people swim in the Northern Territory in the summer, as there are no "stinger-resistant" enclosures, whereas most Queensland cases occurred within the nets in the hottest time of the year when many people swim inside the stinger-resistant enclosures. Stinger-resistant enclosures are nets suspended under a floating pontoon and weighted at the bottom to sit on the sea bed. They may be up to 75 m^2 and are winched in and out with the tide so that they enclose a safer area to swim. These enclosures are usually patrolled by lifeguards. Because they have to be winched in and out, they are unable to be used in locations with a high rise and fall of the tide and a low beach profile, as the winches cannot pull them up over long sections of sand.

The net mesh size is 16 mm (corner to corner). This is more than sufficient to keep out the potentially fatal *Chironex* specimens, which are large, but not small enough to keep out the much smaller Irukandji (2–12 mm diameter). Therefore, many Irukandji stings occur inside these stinger-resistant nets.

Although wading in shallow water (eg, launching a boat) is seen by some to be an acceptable-risk activity at any time of the year, many people are reluctant to enter deeper water until after May 1—the start of the supposed "safe" dry season. Our data show that May is not stinger-free, as is commonly thought, and provide a plausible explanation for the high proportion of stings that occur in the Northern Territory during this month.

Differences in the prevalence of Irukandji stings in Queensland and the Northern Territory are of interest. Relatively few Irukandji stings appear to occur in the Northern Territory. Although it may be argued that Irukandji jellyfish may be less common in the Northern Territory, this phenomenon also may be due to avoidance strategies, given that there are no stinger-proof enclosures in the Northern Territory at present for the reasons outlined. Thus, people are less inclined to swim at the beaches during the summer months, because there are larger numbers of *Chironex* in the water and, possibly too, because there is a better knowledge of the problem, as there are more *Chironex* warning signs in the Northern Territory. There is also the increased promotion of the dangers of crocodiles. Although most people seem to associate this reptile with creeks, there have been a number of beach closures due to the presence of crocodiles off patrolled beaches, both in the Northern Territory and North Queensland (P.J.F., unpublished data, 1999).

The reduced information available on the site of envenomation for Irukandji is due to the fact that most stings occur by contact with the bell of the jellyfish as it actively swims along "bumping" into swimmers. Stings from tentacles occur less often. As the initial sting is minor and there have never been reports of tentacles remaining on the skin (unlike *Chironex*), local treatment or removal of tentacles is not necessary. In contrast, most stings from *Chironex* occur when people blunder into trailing tentacles as the medusa swims slowly along in shallow water with tentacles extended, "fishing" for its prey of small fish and prawns, which are most plentiful in the shallow sandy beaches—those also preferred by their human victims.

It is encouraging to see that a high percentage of both Irukandji and *Chironex* stings were treated with vinegar, showing that this promoted first aid treatment is being widely used by the general public, and also that vinegar is readily available at many places where envenomation does, or may, occur. Unfortunately, inappropriate first aid treatment is still a problem, despite the widespread publicity of the appropriate first aid treatment over many years. The majority of *Chironex* stings that were not treated with vinegar had sand rubbed into the area. This process causes discharge of the remaining undischarged nematocysts and makes the envenomation worse. The large influx of tourists into Australia makes educating the general public very difficult. Also, indigenous tribes prefer to use their more traditional tribal methods of treatment (eg, rubbing the remaining adherent tentacles with sand). This approach may have contributed to a recent fatal *Chironex* sting in Australia, in which hot sand was rubbed into a small area of tentacle remaining on the skin on a young child, greatly increasing the extent of envenomation and probably converting a nonfatal sting into a fatal one.

More *Chironex* and Irukandji stings occur on warmer days. *Chironex* stings occur most frequently on hot still days, with some 90% of stings occurring when there is little or no wind, and particularly on days when there is no rain or very light rain. However, contrary to popular opinion, stings can still occur on windy and rough days, although an Irukandji sting is a more likely event than a *Chironex* sting in rough conditions. Hot still weather occurs commonly in Queensland during the balmy light northerly summer winds.

Rainfall previously has been claimed to influence Irukandji stings,[13] although that study was only based on limited data (2 halves of summer seasons). In the current study, approximately 70% of stings from both Irukandji and *Chironex* occurred on days with no rainfall at all. However, *Chironex* stings did occur more frequently on cloudy days, while Irukandji stings tended to occur mostly on relatively clear days ($\leq$ two eighths cloud cover).

The tide and the phase of the moon may influence the prevalence of *Chironex* and Irukandji stings, as they are both more common on an ebbing tide and during the last quarter of the moon.

Conclusion

Envenomation by both *Chironex fleckeri*, the multitentacled box jellyfish (chirodropid) in northern Australia, and the Irukandji jellyfish (*Carukia barnesi* and related species) remains common in tropical Australian waters. Although deaths from the *Chironex* box jellyfish have been reduced in frequency during the past 10 years, probably due to increased knowledge or awareness, publicity, and the use of stinger-resistant enclosures and protective clothing,[1] stings from Irukandji have not.[9] Sting frequency from Irukandji varies from year to year, presumably due to weather and water patterns influencing their life cycle and feeding patterns.[9]

Although *Chironex* stings are more common on warm (31°C or more) days, they are present throughout the year in areas close to the equator (eg, Northern Territory). Further from the equator *Chironex* are less common, or absent, in winter months. Stings from *Chironex* are more common on cloudy days when there is little or no wind, but do occur, albeit less often, on windy and sunny days. Such factors cannot suggest a "safe" time to swim, although bathing within stinger-resistant enclosures is usually very effective in preventing *Chironex* stings. *Chironex* sting numbers have also been reduced by the wearing of full-length Lycra suits, which prevent a major life-threatening sting.

Irukandji stings occur on warm (31°C or more) days and more commonly when the skies are clear, although stings do occur with any sort of cloud coverage. They are more common when there is little or no wind, but more than 30% of stings occur during winds of mild to moderate intensity. More than 70% of Irukandji stings occur on days with no rainfall. As Irukandji are small and penetrate stinger-resistant enclosures, not only are there no safe predicted times to swim in summer months, the majority of stings at present actually occur within the enclosures. Although full-length Lycra suits reduce the risk by diminishing the exposed body surface area, a single sting can produce the full-blown Irukandji syndrome, with its suffering and need for hospital treatment and possible admission. Again, although stings are more common in both species in the last quarter of the moon and on an ebbing tide, this information is not sufficient to help in predicting safe swimming times.

Summer months are high-risk times for stings, whereas during other times of the year the risk becomes very low. Unfortunately, this study was unable to predict exact weather patterns, or any other definite predictors, to reduce the incidence of stings to an acceptable level; we were only able to identify those factors that increase the likelihood of stings. Our findings also suggest that the stinger-free season reported on *Chironex* warning signs is inaccurate. Therefore, there are only times when the bathing public can be warned of a "significantly increased chance" of stings from dangerous jellyfish such as *Chironex* or Irukandji. However, as well as advising of the high-risk season, these signs should indicate that there is a low risk of *Chironex* and Irukandji stings occurring in most months in Queensland and year round in the Northern Territory.

Much work remains to be done to discover the ecology and life cycle of *C barnesi* and similar small box jellyfish causing the Irukandji syndrome. Surf Life Saving Australia currently has a study underway. Even this knowledge may not help reduce sting numbers. Additional methods, including better education, are needed.

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